



STUDENT GUIDE

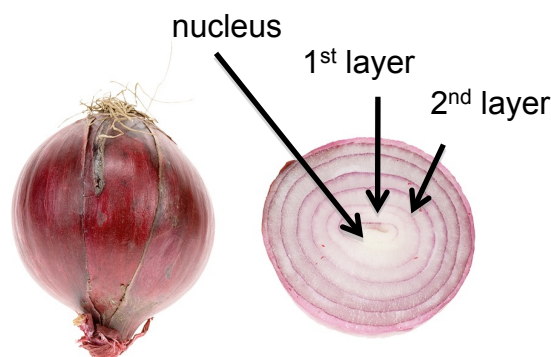
Protons and Electrons

Part I: Protons, Electrons. and Neutrons

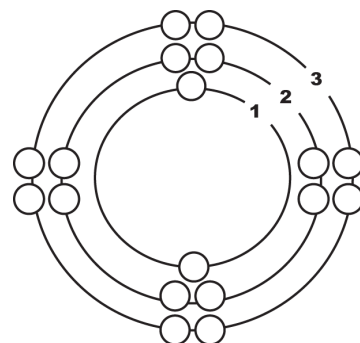
In this activity, you will use models and diagrams to explore how electrons fill the area of the atom called the electron cloud.

So, what is this electron cloud? It is not like the clouds that can be seen in the sky. Instead, an electron cloud is a way to represent an area of space around the mass-containing nucleus of the atom. Electrons do not orbit the nucleus like planets around the Sun. Think of electron movement as swarming, like bees around a hive. However, there is organization within the electron cloud.

Electrons are usually found within a “layered area” of the electron cloud. The electrons fill up the electron cloud in a specific order. Use the picture of the onion to the right to represent an atom. Think of the onion layers as a way to illustrate layer positions within an electron cloud. The layer that fills with electrons first is the layer CLOSEST to the nucleus, then the second layer, and so on.



Each layer is an energy level. The layer closest to the nucleus is the first energy level. The next layer is energy “level 2” and so on. The diagram to the right shows the energy levels of the electron cloud surrounding the central nucleus.



Only the first three energy levels of an atom are shown on this diagram. The circles on the diagram represent spaces within an energy level that can be filled by an electron.

Look at the diagram and answer: How many spaces are available for electrons in the first energy level of an atom’s electron cloud? How many spaces are available for electrons in the second energy level of an atom’s electron cloud? The third?

Remember, only the first three energy levels are shown on this diagram because you will only investigate the first 18 elements.

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Part I: Protons, Electrons, and Neutrons, continued

The information in each box on the Periodic Table provides you with all of the information you need to determine the number of protons, neutrons, and electrons in a neutral atom.

1
H
1.008
Hydrogen

← Atomic Number = Number of Protons

In an electrically neutral atom, the protons and electrons are equal.

← Atomic Mass (rounded) minus Number of Protons = Number of Neutrons

You will use a Periodic Table to make models of the first 18 elements and determine the number of protons, neutrons, and electrons.

Procedure

1. Build a neutral hydrogen atom with a total mass of 1 amu and atomic number of one on the *Student Reference Sheet: Atomic Structure* provided by your teacher.
 1. Place one proton (black bean) on the nucleus of the handout because the atomic number for hydrogen is 1.
 2. Do not place any neutrons on the nucleus because the total mass minus the proton mass is equal to 0. (1 amu total – 1 amu for each proton = 0 amu from neutron mass contribution)
 3. Place one electron (lentil) in either circle of the first energy level on the handout because in a neutral atom the number of negative electrons is the same as the number of positive protons.
 4. Use the model you built to complete the diagram of this hydrogen atom in your *Student Journal*.
 - a) Fill one of the empty circles on the first energy level with a red colored pencil to represent one electron on the *Student Journal* diagram. This example has been done for you, look at it!
 - b) Write p⁺ in the nucleus of the diagram to represent one proton. This example has been done for you.
 - c) Complete the questions for this atom at the side of the diagram. This example has been done for you.
 5. Disassemble the hydrogen atom you built on the *Atomic Structure Handout* to prepare for the next atom.

Continue with Part I on the next page.



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Part I: Protons, Electrons, and Neutrons, continued

2. Build a neutral helium atom with a total mass of 4 amu and atomic number of 2.
 1. Place two protons (black beans) on the nucleus of the handout because the atomic number for helium is 2.
 2. Place two neutrons (navy beans) on the nucleus (4 amu total – 2 amu from protons = 2 amu from neutrons).
 3. Place two electrons (lentils) on the first energy level on the handout (one on each circle) because in a neutral atom the number of negative electrons is the same as the number of positive protons.
 4. Use the model you built to complete the diagram of this helium atom in your *Student Journal*.
 - a) Fill two of the empty circles on the first energy level with a red colored pencil to represent two electrons on your Journal diagram. This example has been done for you.
 - b) Write $2p^+$ in the nucleus of the diagram to represent two protons. This example has been done for you.
 - c) Write $2n^0$ in the nucleus of the diagram to represent two neutrons. This example has been done for you.
 - d) Complete the questions for this atom at the side of the diagram. This example has been done for you.
 5. Disassemble the helium atom you built on the *Atomic Structure Handout* to prepare for the next atom.
3. Build a neutral lithium atom with a total mass of 7 amu and an atomic number of 3.
 1. Place three protons (black beans) on the nucleus of the handout because the atomic number for lithium is 3.
 2. Place four neutrons (navy beans) on the nucleus (7 amu total – 3 amu from protons = 4 amu from neutrons)
 3. There are three electrons (lentils) in a neutral lithium atom. Place two electrons on the first energy level, and one electron on the second energy level (in any of the circles), because in a neutral atom the number of negative electrons is the same as the number of positive protons.
 4. Use the model you built to complete the diagram of this lithium atom in your *Student Journal*. Again this is an example that has been done for you.
5. Continue building neutral atoms for the first 18 elements of the Periodic Table. First, build the atom on the handout using the black beans, navy beans and lentils. Then transfer the information to your *Student Journal* diagram and complete the table to the side for each. Disassemble the atoms after completing each diagram.

Complete Part I in your *Student Journal*.



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Part II: Valence Electrons and Reactivity

How atoms combine with each other to form new substances depends on the number of electrons in the highest energy level. Think of this level as the skin of the atom. It is only the number of electrons in this outer layer that controls how or if atoms react with other atoms.

This controlling layer is called the valence shell and electrons in the valence shell are called valence electrons. Look at the diagrams you built for hydrogen and helium. Hydrogen has one valence electron and is not full because one of the two spaces on the valence shell is empty. Helium has two valence electrons and is FULL because the lowest energy level can only accept two electrons. Look at your diagram for lithium. Lithium has one valence electron. The second energy level can hold 8 electrons, so the valence shell is not full for lithium.

Again, the first shell can hold up to 2 electrons, the second shell can hold up to 8 electrons, and the third and fourth can hold up to 8 as well. This makes 2 and 8 key numbers. They tend to combine so that their valence shells are full of electrons. This is called the octet rule. (Note the root oct = 8 in the word octet, like octopus!).

This means two things:

1. If a neutral atom's valence shell is full, then the atom will not react with other atoms.
2. If a neutral atom's valence shell has space available, then the atom will react with other atoms based on the number of electrons found in the valence shell.

Some atoms only need 1, 2, or 3 more electrons to fill the valence shell. There is a tendency for these atoms to gain electrons from other atoms when they react.

Some atoms need to lose 1, 2, or 3 electrons to have the energy layer below become the valence shell that is already full. There is a tendency for these atoms to lose electrons which are in turn accepted by other atoms when they react.

Some atoms tend to react with other atoms by sharing electrons rather than giving up or receiving electrons. Atoms with 4 valence electrons will likely share electrons with other atoms to fill the valence shell.

Complete Part II in your *Student Journal*.



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Part III: Identifying Elements

What makes fluorine “fluorine”? Or sodium “sodium”? We know they are both made of protons, neutrons, and electrons. We just learned that atoms can give up, accept or share valence electrons with other atoms when they react, so we can’t count on the number of electrons staying the same for any particular atom.

What about protons or neutrons? Protons and neutrons are not given up, accepted, or shared with other atoms. And remember, the number of protons is the same as the atomic number, which is pretty convenient because the atomic number is printed by each element on the Periodic Table.

Go to your *Student Journal* and try to identify some mystery atoms. After completing your predictions using the clues provided, your teacher will identify each of the mystery atoms.

Complete all remaining questions in the *Student Journal*